3 Cybernetics
Thinking Through the Technology

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Cybernetics, in its modern guise, was reborn in 1948 with the publication of Norbert Wiener's book *Cybernetics.*[1] The name was intended to bring focus to "control and communication in the animal and the machine," which was the book's subtitle. In his follow-up, *The Human Use of Human Beings* (Wiener 1950, with a second and much improved edition in 1954), Wiener commented "Until recently, there was no existing word for this complex of ideas and . . . I felt constrained to invent one."[2] He saw the new subject as the outcome of a co-operative process.

These bald statements are an enormous simplification. They are little more than captions, as I indicate by my choice of words. During the Second World War, boundaries across science, and certain aspects of scientific conservatism, were temporarily replaced by an untypical, speculative openness. People took risks, worked across subjects, gave mindspace to the bizarre. Interdisciplinarity was perhaps the great development in working practice.

THE ORIGINS OF CYBERNETICS

Two Sources

Modern cybernetics came out of two sets of meetings that started in World War II and continued thereafter. First, there were dinner parties Wiener held with colleagues at the Massachusetts Institute of Technology (MIT). Wiener had discovered that his colleague, the Mexican neuroscientist Arturo Rosenblueth, and he shared many understandings (particularly of mechanism) across their different fields, hidden by different jargons. Along with others, they met to search for shared understandings, each learning from the advances made in the other's fields.

Second, there were the Josiah Macy Jr. Conferences, chaired by Wiener's MIT colleague, neurophysiologist Warren McCulloch, with the mission to examine what was noted in the MACY Conference title as "Circular Causal and Feedback Mechanisms in Biological and Social Systems." The conferences ran in 1942, and then from 1946 to 1953, generating proceedings (edited by Heinz von Foerster and others) from 1948 to the end (republished by Pias in 2003).[3] There was a glittering list of regular members, including Wiener, who was a member of this group until the 1952 conference. Distinguished guests, such as W. Ross Ashby, were invited for particular conferences.

The Macy conferences had a living system bias, but both groups worked toward creating what Macy participant Margaret Mead[4] later called a common language that allowed people working in different subject areas to better communicate with each other and to find analogies across fields; i.e., general cases developed from particular instances in particular fields, which could be applied to other instances in other fields. Both groups, without favoring behaviorism, were interested in the behavior exhibited by systems.

Two Books

Wiener's two books reflect the difference between the two groups. His first, *Cybernetics,* is grounded in physics and mathematics and is challenging even for a mathematician. Consequently, its readers saw cybernetics as technical and engineering based. *The Human Use of Human Beings* is altogether more philosophical and social, better reflecting the Macy Conference concerns. It is a pity that Wiener published in the sequence he did. The confusion between these two overviews, and the general expectation that cybernetics is a technological subject, has not helped the subject.

Cybernetics and General Systems Theory

The Macy thematic statement uses the word "system." Around the time that cybernetics was reborn (1946), the first article specifically on general systems theory (GST) was published by the biologist Ludwig von Bertalanffy. He claimed to have developed this theory in lectures starting in 1937. Simplistically stated, Bertalanffy's GST was the base that spawned the assorted variety of systems sciences that we have now.[5]

Cyberneticians and systemists have always understood that there was a connection between their two fields. Some see the terms as synonyms. Often it seems the subject that is given precedence is the one in the name of the department where people studied: to systemists, cybernetics is a subset of systems, whereas to cyberneticians, systems is a limited area of cybernetics. People such as Gordon Pask insisted they didn't care what name was used; but Pask stuck to cybernetics. Hopefully these attitudes are changing. What is clear is that GST cannot lay exclusive claim to the word "system."

I introduced modern cybernetics as being "reborn." Cybernetics has a long history, which predates the notion of a systems theory by some considerable time. For instance, Socrates, according to Plato, held that "Cybernetics saves the souls, bodies, and material possessions from the gravest dangers."[6] The name derives from the Greek for helmsman: κυβερ. Socrates used the metaphor of steering a ship 2500 years ago. Greek is also the source of the Latin word *gubernator* (governor). Ampère makes this clear in 1843: "The future science of government should be called *la cybernétique*."[7] He takes his cue from mechanical "governors," such as Watt's, as much as from a notion of a (political) governor. Add to governor and steering the word "regulator," and you have key words of early modern cybernetics.

So is there a substantive difference? Cybernetics seems to be more general, more philosophical, and more abstract than systems theory, which seems full of subdivisions, more pragmatic and more "real world." Perhaps cyberneticians are fascinated by questions whereas systemists like answers. Cybernetics is also essentially concerned with dynamics: Charles François, who compiled and edited the massive *International Encyclopedia of Systems and Cybernetics* (as indispensable as it is unaffordable), characterized cybernetics as the dynamic complement of systems.[8]

Subject and Metasubject

One aspect of cybernetics that needs comment is its status as both subject and metasubject. Like mathematics, cybernetics is a subject used to comment on other subjects, particularly to bring them together by showing common processes and mechanisms. It is also, like mathematics, a subject in its own right. This is a difficult balance, and cybernetics is sometimes expected to fill one role when it is filling the other. Is cybernetics a focused subject or an umbrella-like metasubject? It is both, often (and confusingly) at the same time: there is, as I discuss below, a "cybernetics of cybernetics."

Decline

Modern cybernetics was hailed in its early years as a superscience, but already by 1956, only eight years after the publication of *Cybernetics*, there were problems. One area in which cybernetics was influential was the emerging discipline of computation. Those whose interests were in the uses of general purpose digital computers saw the potential to create an "artificial intelligence" (AI) and believed that this should be the proper subject matter of cybernetics. Others, including the majority of the "founders," saw cybernetics as much broader. The difference reflects the dual aspect of the subject: the AI group saw cybernetics primarily as the subject in itself, while the others saw it as a metasubject. The difference came to a head at a 1956 meeting at Dartmouth College, where AI was formally born. Promising specific and militarily useful outcomes, the AI group gazumped the host subject and its funding at a time when the US military was the major source of research funds in the United States and elsewhere. The fact that few of the promised outcomes were attained seems not to have been noticed, and while AI prospered, cybernetics declined in funding and in recognition. Nor was AI the only cybernetic surrogate: bionics (the engineering emulation and amplification of biological processes) also flourished for a period. Wiener's wish to make sure that there was a balance of power, which involved briefing the Soviets on American developments in the subject, did not help.[9] By the start of the 1970s, cybernetics had largely disappeared from university campuses and more generally worldwide, except as a synonym for control engineering, especially robotics. The enactment by the US Congress of the Mansfield Agreement (1969) (although later relaxed), which prohibited military funding of research lacking direct military application, did not help: technology had won over philosophy.[10] Cyberneticians, with their early claims, which were often wildly ambitious, also contributed to a loss of credibility.

Not the End: Second-Order Cybernetics

But this was not (as some have asserted) the end of cybernetics, even if the subject has since remained low on the horizon. In the 1968 paper already cited, Margaret Mead, one of the original Macy group, addressed the American Society for Cybernetics (ASC), a learned society founded in part as a reaction to the dominance of the computational paradigm of AI, and asked that this new (cybernetic) society consider itself in a cybernetic manner. Her address, called "Cybernetics of Cybernetics," requested consistency: the ASC should behave in a manner reflecting the reflexivity implicit in the approach and knowledge it fostered. Heinz von Foerster, in what is the "official origin" of second-order cybernetics, took Mead's message and applied it to the observer. He talked of a first-order cybernetics of observed systems and a second-order cybernetics of observing systems.[11] In other words, an observer of the system (first-order cybernetics) contrasted with an observer in the system (second-order cybernetics), as I like to put it (Glanville 2005). This is the official origin of second-order cybernetics.

Second-order cybernetics does not preclude first-order cybernetics. Technological cybernetics of control engineering, dealt with in Wiener's first book, survives largely oblivious to and untouched by second-order cybernetics. It remains powerfully effective at what it does. Second-order cybernetics is more philosophical and closer to the concerns of Wiener's second book. It examines what it means when the observer is in the system, normally a scientific taboo. Nevertheless, this issue is important not only for many nonscientific activities but also in many areas of science. Perhaps we might consider this in the following way: science and cybernetics are both concerned with consistency and repeatability, but in science repeatability is valued over consistency whereas in cybernetics this is reversed.

Second-order cybernetics is concerned with the study of circularity wherever it occurs. Consider, for instance, that the observer (sensor/switch) that makes up the "controller" in a thermostatic system has a circular relationship with the rest of the system: this is standard (first-order) cybernetics, which will surprise no one. However, the observer describing this system is also connected to the system in a circular relationship, even if this circularity in his/her observing is rarely noticed (for humans are affected by what we observe: we form, test, and develop concepts). Indeed, we might think of the linearity we presume in most descriptions of observing as a special, limited case of the circular—limited in the sense that we understand the returning (circular, feedback) component as so relatively weak that we don't have to worry about it, undoing the more general circularity so it becomes apparently linear. To treat the observer in both conceptions (first order and second order, linear and circular) in the same way is to invoke consistency.

Opponents argue that second-order cybernetics proposes a solipsistic way of looking at the world: that the inclusion of the observer makes knowledge of systems subjective and open to wishful thinking. Nothing could be further from the case. Second-order cybernetics demands that we test the descriptions we generate (of behaviors) in the way all science is supposed to but sometimes fails to. It simply provides us with an environment in which, and collection of tools with which, to examine systems that incorporate the observer rather than rejecting him/her. It responds to the assertion "Objectivity is a subject's delusion that observing can be done without him," recognizing that the world we inhabit is a world of our experience. Failure by some adherents to live up to these criteria is no basis for rejecting them out of hand any more than the failure of some humans to behave honestly is a reason to reject honesty. Rather than promoting solipsism, second-order cybernetics has a strong relationship with philosophical radical constructivism, which argues that we can neither assert nor (as importantly) deny the existence of a "mind independent reality."[12] However, not all cyberneticians accept second-order cybernetics, or the progression I outline.

Not First-Order, Not Second-Order: Just Cybernetics

The initial theoretical working out of second-order cybernetics as a position occurred roughly between 1968 and 1976. Some feel that cybernetics since then has been waiting for the next great insight. I disagree: I see extensions of the original formulations, and a growing understanding that second-order cybernetics is at least as old as first-order: that the distinction might be dropped.

I see two other developments. The first is that, if one looks back at the early work for which cybernetics was named by Wiener, one sees the observer was often included, although sometimes implicitly rather than explicitly. In my view, the Macy conferences were already implicitly concerned with second-order systems, so cybernetics can be thought to have begun a second-order cybernetics. First-order cybernetics was a simplification that turned into a strategic error. Consider discussions of creativity and intelligence, so important in AI. The current, slow replacing of definitional, algorithmic, outside-view approaches might not have been necessary had the AI pioneers known of the cybernetics of Gregory Bateson,[13] who insisted, in discussing creativity, that when humans use computers (raising the question, is the computer or the human creative/intelligent?), creativity exists not in one or the other but between the human and the computer working in a particular context. This understanding of second-order cybernetics was glossed over in the rush to create a technology that is AI, all the while ignoring an inconsistency between the epistemological stances of the subject itself and that of the observer describing it.

The second reaffirms an understanding of the relationship between theory and practice. Culturally, we have tended to give precedence to theory—as expressed in assertions such as "Don't act until you understand." Yet, as Piaget has shown us, our learning, when we are children, begins with action (practice), from which we develop understanding (theory).[14] Second-order cybernetics sees practice and theory (like action and understanding) as linked in another circularity with precedence given to neither (see diagram below). We can enter the circle of practice/theory (acting/understanding) from either concept, inevitably proceeding to the other and then back to the concept through which we entered. Following Schön, practitioners such as designers have begun to explore, researching in and through their practice, building a body of research that recognizes their practice as equal to theorizing, an approach that is both inspired by second-order cybernetics and deeply antagonistic to the views of more traditional design researchers who look for a more classically "scientific" understanding (and its application) based on linear causality. In this new approach, designers can see what they do (their professional activity) as worthy of research, developing theory from this work rather than being confronted by an alien type of research that simply fails, in its imposition, to recognize what designers do. While not exactly the same, evidence-based research shares this view: we are to value what we experience. Observe and do. An approach to a more cybernetic type of research (in design, through practice) can be found in Glanville and van Schaik, where a doctoral program that particularly values practice is described.[15] We will discuss this in greater detail toward the end of this text.

Many fields have, to use a metaphor, taken from cybernetics, which they have treated as a toolbox, without returning the tools. They have failed to see the stronger coherence existing in the tool set, forgetting its source and history. Nowadays, we find the name "cybernetics" popping up in many guises, usually not well related to the original. We also see "problems" that cybernetics dealt with many years ago reappearing as if new. These problems often reappear in exactly those fields that have taken from cybernetics without giving due credit and without care for coherence and consistency. The current fascinations with self-organization and complexity are but two examples.

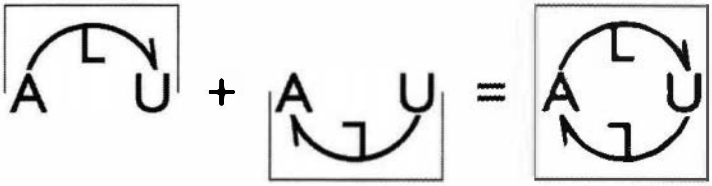

Diagram 3.1 The basic model of communication used by Shannon and Weaver. The message is encoded (for instance, speech is converted into a radio signal) and transmitted. Noise (unwanted modifications to the radio signal) enters between transmission and receipt before the resulting, accidentally modified signal is decoded and received as a slight modification of the message.

CYBERNETIC INVESTIGATION

Cybernetics is concerned with behavior. Although Wiener is generally recognized as the father of cybernetics, many believe Ashby's 1956 *Introduction to Cybernetics* is the best general formulation of what it is. Ashby, a psychologist, presented cybernetics through the metaphor of machine with input and output, which became the central metaphor for the investigation of cybernetic systems. A machine should be understood not through an industrial image of cogs and levers, but as a connected suite of mechanisms, specifying predictable, logically consequent, and reliable outcomes of specific actions, revealed as changes in behaviors. As Ashby wrote: "Cybernetics does not ask 'what is this machine?' but 'what does it do?' "[16]

In Ashby's machine, a mechanism connects the in- and outputs causing the input to become the output. Von Foerster divides input/output machines into trivial (predictable machines) and nontrivial (unpredictable machines that learn).[17] On occasion, when we do not know what connects input and output, we use a "Black Box" (a thought experiment devised by the physicist James Clerk Maxwell), which allows us to postulate a mechanism converting a set of inputs into a set of outputs. In my interpretation, we do not know what is inside the Black Box (the Black Box is, itself, a postulate).[18] Any mechanism we propose works while it works: it has viability without actuality. Some confuse the Black Box with the nontrivial machine, but they are essentially different.

Ashby suggests we often face a situation in which we treat what faces us as a Black Box: for instance, when faced with a door handle, a child learns to use it without any idea of what's going on in the mechanism. Ashby speculates that we may treat everything we encounter as a Black Box, including each other.[19] Thus, when faced with a door handle, we do not need to know what happens "inside," but what moving the lever does; and we develop an understanding that allows us a good guess without ever knowing what the hidden mechanism is. The "actual" mechanism doesn't matter: what matters is that we can open and close doors.

Cybernetic investigation uses the metaphor of the machine as a way of explaining behaviors. It also builds machines to behave in such ways. But it still realizes the limits of the machine metaphor, that it is only when the mechanical behavior breaks down that the investigation is teaching us something new, using Foerster's term, that it is nontrivial. The Black Box allows us to imagine a machine that is not only nontrivial, but one for which the notion of triviality has no relevance. The investigator (Ashby's name for the observer) is always present: the system includes him/her. The devices cybernetics has developed for its investigations are in many ways superb models for a modern, skeptical science, based on the notion of explanation by humans.

KEY CONCEPTS

What are cybernetics' key concepts? I have arranged them in four subgroups consisting of error, subtitle, state, and circularity concepts. My choice, and grouping, will not be universally accepted. I have omitted concepts such as self-organization, and also thinkers others might consider of primary importance. Different groupings are possible; and several selected concepts could (and do) appear under more than one heading. As we will see, this is to be expected when we take a position informed by second-order cybernetics.

1) Error Concepts

Probably the best-known "cybernetic" concept, often taken as synonymous with the subject, is "feedback." Feedback provides a way of dealing with something far more ubiquitous: error. Without error, we don't need feedback and may continue to understand the world in the image of Newton's idealized, perfect machine.[20] Cybernetics is distinctive in accepting the ubiquity of error. Newton's model aims for idealized and unchanging perfection, while the cybernetic worldview assumes error is omnipresent. We may reduce it, manage it, alleviate and counteract it, but it persists. It is not an inconvenience that we can get rid of.

In cybernetics, error was initially seen as divergence from a desired path, or a failure to attain some goal point. Early on, Rosenblueth, Wiener, and Bigelow wrote of systems with intentionality: systems that were not simply mechanical but intended to achieve something (for instance, an antiaircraft shell hitting a plane in flight).[21] The introduction of purpose into a system (under the term "teleology") was brave, risking scientific scorn because it betrays a wish to steer the action rather than remain in a neutral state. When examined in this purposive way, failing to hit the plane registered as an error to be measured and corrected. The potential to miss some goal was assumed.

Cybernetics contributed a means of communicating success (or a lack of success) in attaining a goal and an indication of the nature of the miss. The means of communication is a channel passing "feedback" to the actor-agent operating the system, allowing the actor-agent both to recognize there had been an error and to adjust the system so as to reduce this. (Error-reducing feedback is called "negative feedback." Contrastingly, when feedback increases the error, it is called "positive feedback." Probably the best-known example is the rapidly increasing howl that amplifiers can produce.)

A further aspect of purpose is that the system's goal is chosen (by an actor-agent). The operation of the system is through a loop. The behavior of the actor-agent is determined by both the goal (which (s)he usually sets) and the signal (s)he gets back concerning the success of the instigated action. This contrasts with the simple and direct cause and effect normal science gives us.

The system becomes a cybernetic system as a result of the error being reported back: the cybernetic system responds after the event. Cybernetic behavior in a system comes about through continuous testing, checking, acting to change (if necessary), and testing again. This is the circle of that key cybernetic activity, control, which we come to in the next section.

2) Subtitle Concepts

The subtitle of Wiener's book *Cybernetics* is "or Control and Communication in the Animal and the Machine." The subtitle is often taken as a definition, with the phrase "the science of" inserted at the start, but this addition is not in Wiener's original.

The subtitle divides into two parts. The first deals with control and communication, the second with the animal and the machine. The phrase "the animal and the machine" defines the areas in which cybernetics operates, making it specifically both broad and interdisciplinary. Mead, as already noted, saw cybernetics as providing a language, allowing us to cross between disciplines. Cybernetics should provide a way of thinking that allows discussion of both the animal and the machine, a distinction embodied in science as the distinction between biology and mechanics/physics. Error correction (regulation) through feedback is a behavior exhibited by both animals and machines. Descartes's favoring of a mechanical metaphor to explain the living had long been familiar by the 1940s when (for instance) medics discussed the human body in mechanical terms such as "lever."

First-order cybernetics promoted this metaphor (e.g., the brain as computer—for instance, see Arbib and Beer;[22] and although Ashby's re-creation of the biological phenomenon of homeostasis (the ability of a system to return to its normal, stable state in the face of arbitrary perturbations) in a machine—the "homeostat"—might be thought of as the realization of an animal metaphor, Ashby's homeostat was innovatory when introduced.[23] It was another fifteen to twenty years before Humberto Maturana introduced the concept of "autopoiesis" in a paper coauthored with his student Francisco Varela (who formalized the concept mathematically) and his colleague Ricardo Uribe (who created an automaton that simulated autopoietic behavior).[24] I gloss autopoiesis as Maturana's attempt to present life as a process of becoming and remaining alive (in Greek, auto + poiesis translates to self + production), creating a mechanism for the animate and for the autonomy of form that living things generate. This may be interpreted, in hindsight, as a machine using an animal metaphor. The change from the mechanical metaphor for the animal to an animal metaphor for the machine is another way of conceiving the difference between first- and second-order cybernetic.

Maturana continues working in biology and neurology, where he has developed the "Biology of Love." Varela, who died young in 2001, became interested in consciousness, especially embodied consciousness, and was a scientific advisor to the Dalai Lama. The last collaboration between Maturana and Varela was the book *The Tree of Knowledge*.[25]

The concept of autopoiesis has attracted a lot of attention and has been appropriated (against Maturana's wishes) by scholars working in other fields than biology. Probably the most notable is Niklas Luhmann's adoption of the concept in his own work in sociology and communication, for instance in Luhmann's "The Autopoiesis of Social Systems."[26]

The other pairing in Wiener's subtitle directs us to the heart of cybernetics: control and communication. If error is endemic—the aspect of a system's behavior that gives life to cybernetics—control and communication are the concepts that allow a feedback loop to function, to accommodate and alleviate this error.

There can be no control without communication. The controller's wishes impinge on the controlled through some form of communication. Early cybernetics required messages to be sent from one entity to another so the second entity might act in accordance with the wishes of the first. The means of communication was taken to be a channel through which messages were transmitted. This aspect of cybernetics is difficult to separate from Claude Shannon's (Shannon and Weaver 1948) "A Mathematical Theory of Communication" (known popularly though incorrectly as Information Theory), published in 1949. Shannon, Weaver, and Wiener were close and mutually supportive colleagues, although Shannon's publication created a rift.[27] The power of Shannon's understanding is seen in the extraordinary communication and control systems we have today; but there are serious questions about how it helps with human communication, a critical matter for many of the Macy participants and those who have since come to sympathize with them.

Communication is a prerequisite for control; but control is the more important key concept. Yet it is a difficult concept for many people because it suggests restriction and imposition. Cybernetic control aims to facilitate. If we have the goal that a room should maintain a particular temperature, controlling the delivery of heat (in a cold climate) facilitates this wish. If we wish to ski down a slope, being able to act to absorb the unexpected,

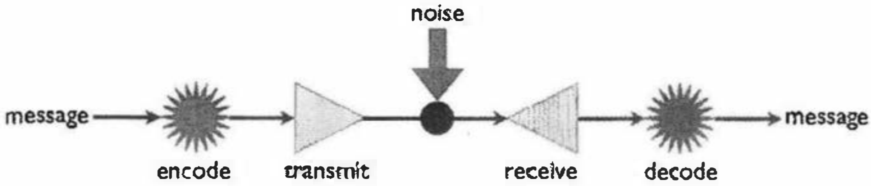

Diagram 3.2 Traditional accounts have an unambiguous relationship between the controller and the controlled. Whenever there is a circular (i.e., cybernetic) system, however, the roles of controller and controlled become less clear. In this case, control exists between the two elements, as shown here in a form of mutual control.

such as irregularities in the physical environment or the sudden appearance of other skiers, is vital. Without this degree of control in our behavior, we would not succeed. In cybernetic terms, for control to be effective, each state that we identify as being one we might have to respond to in the environment (which we call the "variety" of the environment) needs to somehow be mapped into the (controlling) model we have of that environment: i.e., we need at least as much variety in the controlling system as in the system being controlled.

There are systems in which the variety exercised by the controller is (vastly) less than that in the controlled. In these cases, the control is restrictive. One of the worst results is dictatorship. If the controlling system does not have enough variety, it restricts that which is to be controlled. This restrictive form of control is what cybernetics acts against. However, there is a fortunate upside. Consider how the world can be understood as much richer in variety than my brain can ever be. Rather than controlling in a deeply restrictive manner, I may benefit from the variety imbalance by using the variety I do not have as a resource, offering me all sorts of riches I had never imagined![28]

3) State Concepts

We have already mentioned our state concepts. Here we will examine them further.

Let us assume a conventional description of a system as consisting of a number of variables. As determined by some observer, each variable has a number of states the system may attain. The particular state a system is in is, thus, distinct, within the set of states that a variable may take at any moment.

If a state is considered desirable by some observer, it becomes a goal—a preferred state that a system is seen as trying to attain and/or maintain. Some goals are points, like a harbor we sail toward. Others are trajectories, such as a flight path that is followed. Goals are determined by the observer/actor who acts as the actor-agent.

The number of states a system may attain has special importance because it determines what is required so that it may be controlled. W. Ross Ashby introduced the concept of variety, which can be expressed in a number of ways. It measures the states the system may attain, either as a number or as a proportion of the possible states it might attain if not constrained in some way. It is often presented as analogous to entropy, using a similar logarithmic expression. Ashby's argument, expressed in his "Law of Requisite Variety,"[29] is that the controlling system must have at least as much variety as the controlled system: if this condition is not satisfied, some states the system might normally be able to attain will be excluded because the controlling system does not have them, thus restricting performance. Hence the discussion above in the previous section of the role of variety in the two different types of control—facilitative and restrictive. Variety is not, as entropy is, an absolute physical measure. Analysis may be reformulated, and the calculation of the states to be attained and criteria of attainment may alter. A major skill of those interested in big and complex systems is to re-envision a system to be controlled so the requisite variety is reduced. The work of Stafford Beer, the so-called father of management cybernetics, is deeply concerned with variety and variety management, as can be seen in his selected papers.[30]

I used the word "constraint," above. Constraint measures the relation between the variety a configuration might take, and the actual variety it does take. It describes how some of the possible states a system might (in theory) take are not taken up. Often, this provides an advantage: many have experienced paralysis when faced with seemingly limitless variety. Some use constraint to describe what happens when the variety in the controller is less than that needed by the controlled system. I prefer to limit "constraint" to describe a range of possibilities, using "restrict" for variety imbalance.

4) Circularity Concepts

The notion of feedback has already been mentioned several times. Feedback occurs through a channel allowing communication to occur, permitting an actor-agent to decide how successful his/her action has been (did it, and/or does it continue to, attain the goal). Wiener's notion suggested that the energy involved in feedback was tiny compared to that in the "main" action, allowing feedback to be treated as secondary. Hence the actor-agent's action, leading to feedback concerning success in attaining some goal, is understood as the action of the controller. Part of the early cybernetic discussion of control was dominated by the physics of energy, so that which used little energy to control much was taken to be the controller—obvious, perhaps, if you are a physicist, but not so obvious if you are a cybernetician.

If, however, we talk in terms of action and communication rather than of energy, the link between the actor-agent and the objects, trajectories, goals, etc. is circular. The half of the circularity Wiener called feedback is no longer relatively minor (because it is energetically insignificant), but operationally and informationally of equal significance. This matches the conditions as Ashby says, "Cybernetics is the study of the immaterial aspects of systems." Again, using the archetypical cybernetic example, the thermostat, we understand that (in a cold climate) while the switch on the wall controls the provision of heat, the provision of heat controls the switch on the wall. Each element controls the other; each is controlled by the other. The stasis of the system derives from both the (heat) sensor and the (heat) provider elements working together in mutual control and balance to achieve a goal. Cybernetic control is essentially circular: control happens between the elements. It is, in this cybernetic way of looking, impossible to determine which half of the circle is the feedback loop.

We can also interpret control as cause. In a control system, the controller causes the controlled to act as the controller wishes. When control is mutual, each element causes the other to behave in a particular way. The Macy Group's "mission statement" referred to "circular causal and feedback mechanisms." The thermostat operates through a circular mechanism. Thus, we understand from the outset the deep-seated concern of cybernetics with circularity: A controls B and B controls A; the switch controls the heat supply and the heat supply controls the switch. Some behavior in A causes some behavior in B, which causes some (further) behavior in A and so on.

This reconnects us to the cybernetic approach to error. The process of error correction using feedback is one in which the actor-agent controls a (sub)system's behavior, while the system's behavior is used by the actor-agent to determine the next control operation on the (sub)system. As we now understand control, the (sub)system is, in this manner, controlling controls, in this manner, the actor-agent's behavior. Error correction is an unending circular process—for error is endemic and unpredictable.

Cybernetics pursues a behaviorist approach (it observes and tries to account for behaviors), reflected in its mechanical aspect. Through the mechanisms of circularity, the elements, actor-agent and (sub)system, are in some sense changed each cycle around the circle. Thus the behavior of each changes in response to the other. In this sense, the actor-agent's progress around the circle forms a spiral: the circle is like a track, the spiral the experience of circling.

An important note: in a circular system we assume the possibility of similar behavior in each element. Each controls the other; each is controlled by the other. What is possible in one should be possible (in principle) in the other. I have called the notion that, in circular systems, qualities that may be assumed of the one element should, potentially, be assumable of the other "the principle of mutual reciprocity." This is an extension of the Law of Requisite Variety.

We often call a more sophisticated approach to error correction "learning." One way to learn, and we can consider primitive learning, is through error correction. When we think of learning as creating a pattern as we correct errors, extrapolating from a number of specific cases to develop a general understanding through which to modify our behavior, we exhibit learning, and we modify our learned behavior by continuing to test for errors and adapting accordingly, continuing this learning process.

MEAD'S IMPLIED CRITIQUE OF CYBERNETICS: CONSISTENCY

I have recounted how, in her 1968 keynote address to the ASC's first conference, Margaret Mead asked that the ASC learn the lessons of its own subject and apply them to its own functioning and aspirations—both for consistency's sake and to show it valued itself. Foerster provided her with a title, "Cybernetics of Cybernetics."

Mead's intention was managerial: to shape the society to behave cybernetically. She had already noted that the Society for General System Research did not behave systemically. She was concerned that the ASC might become ordinary, traditional, and conventional—in a word, uncybernetic. Foerster (often called the father of second-order cybernetics, but better thought of, in the way that he talked of himself, as its ringmaster) extended Mead's argument in an unexpected way. He took the idea that cybernetics should be self-consistent and applied it to the matter of how cybernetic investigation is carried out.

Here are two moves Foerster made. Please note: these are my explanations, not his. Let me give my accounts of two actions Foerster took. Foerster's first action was to compile a book, the outcome of an elective course taught at the University of Illinois. Also called "Cybernetics of Cybernetics,"[31] it consisted of selected cybernetics texts, illuminated by different cybernetic analyses. The second move was more abstract. In "Cybernetics of Cybernetics" Foerster makes the following differentiation, by now familiar to the reader: first-order cybernetics, the cybernetics of observed systems; second-order cybernetics, the cybernetics of observing systems. I shall attempt to relate this statement to Mead's demand in her keynote address. After all, Mead was the first field anthropologist to work as an active observer, participating with those she studied. She studied as an observing system.[32]

Remember the thermostat. The switch on the wall senses the temperature and "decides" the air is too cold. This action is sensed by the heat provider, which heats the air—which is what the switch senses. When the air is hot enough, the switch ceases to demand heat from the heat provider.

The elements sense each other. "Observe" is a word used in science to indicate sensing. Insofar as control, a key cybernetic activity, depends on sensing, observing is a cybernetic activity. My earlier account of the thermostat insisted each element was controlled by, while also controlling, the other. Substitute the word "observe" for "control," and we have the cybernetics of the observed and of the observing. In first-order cybernetics we consider the behavior of the controlled (observed) element. In second-order cybernetics we consider the controlling (observing). The circularity is of (mutual) observing occurring within the system.

How do we investigate observed and observing in the circularity that is the thermostat? By observing its behaviors. The thermostatic system, itself, has an observer. The thermostat is the observed of another observer's observing. However, in cybernetic systems, control (observation) involves the mutual control (observation) of each element by the other. To be consistent in observing, we must observe our system of interest as we have learned the cybernetic system observes itself. Hence the second-order cybernetics interest in observing, satisfying Mead's demand for consistency: we observe the system as it observes itself. The thermostat and its observer form a circular system. The location of the observer when considered thus changes. Systems can be observed from within and from without: but the view from without forms a new circular system between the (circular) system being observed and the observer (without).

The difference between observing from within and without a system is significant. What may be perfectly stable (continuing as is, without change) when observed from within the system may appear to an outside observer to change: think of how we believe ourselves to be essentially unchanging while to our friends we may seem to have changed a good deal. Cybernetics allows us to understand these differences in viewpoint not as contradictory, but as distinct and often complementary.[33]

Since each observer is understood as different and unique, the observations of each will be different. In the terms that Foerster put this in a conversation with Ernst von Glaserfield: "Objectivity is the delusion that observations could be made without an observer." Second-order cybernetics satisfies Mead's consistency requirement by reformulating the subject so that the investigation of cybernetics occurs in a cybernetic manner.

PHILOSOPHICAL PARALLEL

Second-order cybernetics is more philosophically questioning than the technologically driven first-order cybernetics.[34] In the 1970s, Ernst von Glasersfeld (whose involvement with cybernetics began in the early 1950s) developed a philosophical approach, radical constructivism, that grew out of the work of Piaget and that he related, in title and content, to the philosophies of Vico and Berkeley.[35]

Glasersfeld insisted we live in experience. He argued not that there is no "mind independent reality," but that we cannot know whether there is or is not because we are "wrapped" in experience and our minds do the knowing. For Glasersfeld, knowing is justified through the test of viability rather than of truth: the best we can hope for is that it works, now (this is close to Popper's "Conjectures and Refutations").[36] The knower is always present. Faced with the "undecidable question" of whether there is a mind-independent reality, we may choose (and choose again, differently). There is no "right"—only that which works, under the circumstances and in the particular context. To my mind, we also need an important few whose task is to maintain this undecidability. I count myself among the few.

Thus, Glasersfeld produced an explicit philosophy that comes from the nonexclusion of the knower (observer), creating a parallel with second-order cybernetics. By taking the seven statements of Glasersfeld's "core of radical constructivism" and showing that each is reflected in second-order cybernetics, I demonstrate the close connection between the two.[37] Interestingly, in his seventh core statement, Glasersfeld quotes philosopher Leo Apostel, sounding in 1977 remarkably like Margaret Mead: "A system should always be applied to itself."[38] Glasersfeld understands that radical constructivism cannot be said to be right. It works when and as it works and is but one of the options. And writing about cybernetics, Glasersfeld asserts, "Cybernetics is a way of thinking, not a collection of facts."[39]

WHAT SECOND-ORDER CYBERNETICS CHANGES

Mead's (and Apostel's) requirement suggests that cybernetic investigations should not only report cybernetic behaviors but be executed in a cybernetic manner. A cybernetic investigation of a cybernetic system should be cybernetic in style, based in cybernetic understandings, justifying itself in its own terms. This was not a requirement made of earlier cybernetics![40]

We live with many systems where the observer is inside the system: for instance, Macy's biological and social systems, and in our experience. One way of thinking about social and human sciences, ecology, etc., is to note that throughout their history, they have tried to handle observer inclusion as a problem to be minimized, if not overcome: to construct the system so that the presence of the observer within it, and the interaction between the investigator and the investigated, becomes more like the relationship between observer and observed in Newton's model.[41] Second-order cybernetics takes a different stance, highlighting that the system includes the investigator. It learns how this form of investigation might work and the value of what we might get from the investigation. Characteristically, second-order cybernetics is more interested in learning than in knowledge.

Although many early cybernetic concepts are but slightly affected, second-order cybernetics asks us to reconsider key concepts, for instance, control, communication, and circularity (and concepts associated with them). We will consider each. It also returns us to a more general, philosophical view of cybernetics in keeping with the insights of at least many of the founders, who viewed technological cybernetics as a restricted (but valued) special case. And it leads to a cybernetics in which, using the metaphor of the Black Box, we do not assume we can see inside the box: our explanations are just explanations. Our understanding is based in a lasting and deep ignorance.

1) Control

We have seen how the basic cybernetic activity of control should be considered as circular rather than linear: that is, it is a shared activity within a system. As noted earlier, a control system has two elements: the controller and the controlled, each of which controls the other, so each is controller of the other and controlled by the other.

Ashby's Law of Requisite Variety requires that the controlling element have at least as much variety as the controlled; otherwise the control will not be cybernetic (facilitative) but restrictive. However, in the situation that Ashby apparently did not foresee, when each element is both controller and controlled, the variety of each element must be the same.

This may not be possible. Utilizing the notion of variety and the worldview it espouses, we understand that a group of connected people will have much more variety than one person. Combinatoric differences will be vast, and the only way one could hope to control the group is by massively restricting its variety. Considering ourselves in the universe, it is clear that, as we account for the universe now, there is unimaginably more variety in the universe than in the brain of any of us. This means we are out of control—the universe is unmanageable. The only way we can control the universe is to vastly restrict its variety—to treat it as tiny.

There is an alternative: to give up controlling! Accept the universe as essentially unmanageable. This means at least two things. First, there is a vast source of stuff, potentially new to us, that we can take as a source of personal creativity if we just "keep our eyes open." Second, rather than trying to be in control, we respond to what is on offer to us. We open up our relation to the universe responsively. We learned at the outset that cybernetics is necessarily a responsive approach, so this is a consistent position, modest and humble, familiar to us in several thought systems, for instance Buddhism, which is often characterized as a religion of acceptance and response rather than of proselytization and domination. Buddhist notions of control seem similar to those of second-order cybernetics, too.

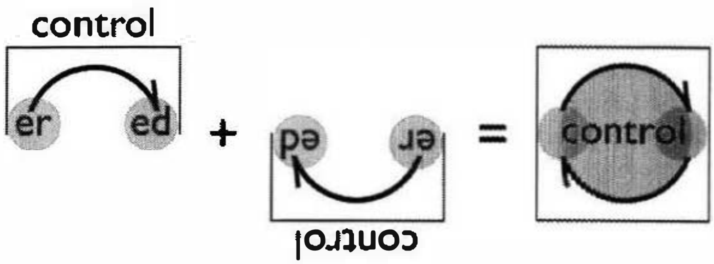

Diagram 3.3

2) Communication

What we all probably treat as the dominant model of communication involves a message encoded, transmitted (distorted), received, and decoded. This is the transmission channel of information theory in Shannon and Weaver's mathematical theory of communication. The point is to get a message from a sender to a recipient without distortion. We assume that the message carries meaning and that the meaning to the receiver is the meaning intended by the transmitter. This is communication by coding.

The moment we assume that the transmitting and receiving observer (actor-agents) are individually different, the transmission of meaning becomes a problem—and the assumptions made in the information theory modeled in Shannon's theory become clear: how could we believe the message has same meaning to transmitter and receiver? We have to test and explore this belief with each other, meaning we cannot assume successful transmission/reception. Code is not given, it's an agreement we arrive at—by negotiation!

If each observer creates his or her own understanding, these understandings are unique to the particular observer/actor and inaccessible to others. How, then, might we communicate? I cannot transmit my meaning to you. I may offer some utterance to which you may give your own meaning. In response, you may make an utterance, and if I find the meaning I generate in response to this close enough to my originally intended meaning, I may believe you "understand" me. Of course, you do not, but your understanding seems to me to "co-ordinate" (as Maturana says) with mine. And if not, I can try again: this is an error-correction action, and either or both of us can take it.

This form of negotiatory communication is familiar: we call it conversation. Conversation is the communication primitive in second-order cybernetics, as it is between humans. Gordon Pask created conversation theory from human conversation to allow students to "teachback" what they had learned in computer-aided learning systems. It has rich consequences. In contrast, a code, such as a fixed meaning of a word, is a *negotiated* agreed restriction.

Conversation is archetypical interaction. Pask's conversation theory is the polar of Shannon's account of how we can communicate. It has very wide ramifications, which Pask explored in three books produced in very short order in the mid-1970s. As Pask accounts for it, conversation is interactive. Pask had been meaningfully concerned with interaction from the early 1950s, building the interactive machines Musicolour and several varieties of Self-Adaptive Keyboard Instructor.[42] Pask's early machines are possibly still the most genuinely interactive machines ever built. Pask's work is, as I have argued in a commentary on his 1961 book, consumed by interaction.[43] In the sense used here, interaction involves an active contribution from both parties, leading, often, to the completely unexpected—as when we find it

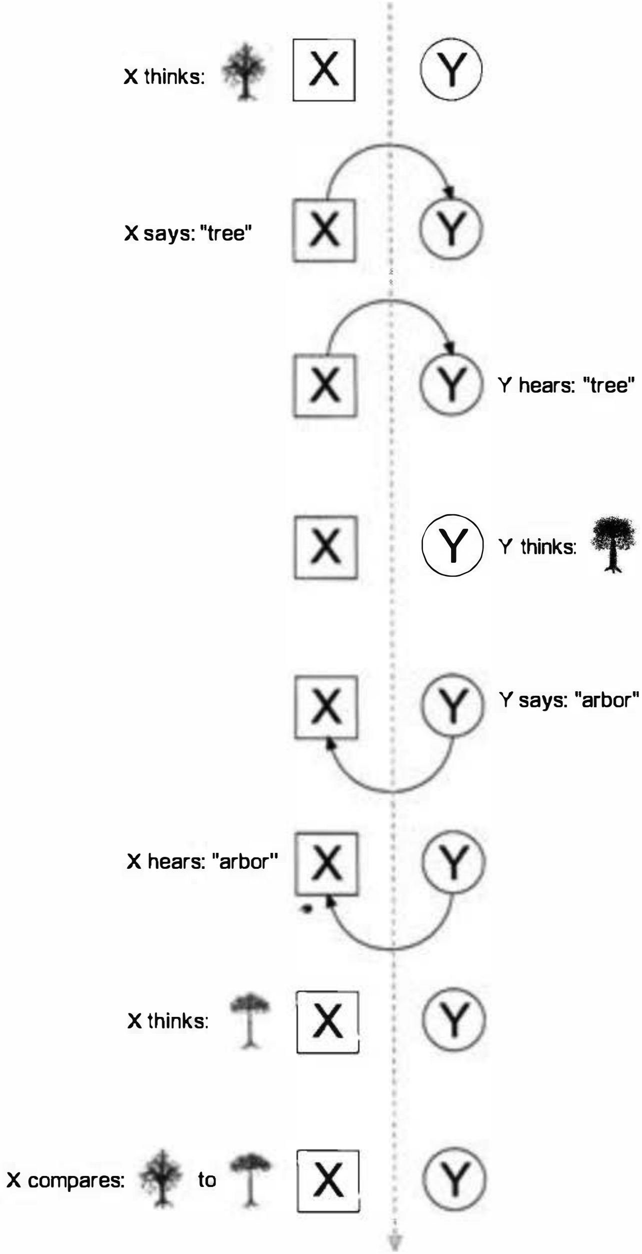

Diagram 3.4 Gordon Pask proposed a type of communication closely modeled on everyday conversation, which allows us to develop personal meanings in parallel with each other and nevertheless to communicate. This diagram shows Pask's structure of conversational exchanges. Depending on the outcome of the final comparison shown, X will determine if Y has understood (constructed a working parallel meaning). If not, X will try again, modifying their earlier attempt.

difficult to explain how we moved from where we began our conversation to where we ended—another source of creativity. Conversation is archetypical interaction. Toward the end of his life, Pask tried to generalize conversation theory into interaction of actors theory, which remained, in my view, inadequately articulated at the time of his death.

We cannot assume utterances have meanings to others (let alone that your meaning and mine would be the same) because meaning is an individual construction. But we can come to agree we will treat words as if they have meanings that we pretend we share. Thus we develop language rather than just utterances. We enter a social as well as an individualist, psychological arena, and can talk both of, and within, language—as Krippendorff would have us do.[44]

We should not leave this section on communication without mentioning Stafford Beer's Syntegration. Syntegration is a process that is contained within a circular communication structure based on the icosahedron, a geometrical and structural form favored by the engineer R. Buckminster Fuller, from whom Beer took inspiration. Each participant is taken as occupying a node and having connections with other, neighboring participants, according to the geometry. A general area of concern is proposed: the icosahedron brings different individuals together to exchange opinions in a coordinated and regulated manner, maintaining the richness of their individuality and dissolving blockages, in part by making these difficulties apparent to all the participants through their structured interactions.[45]

3) Circularity

We have seen that both control and communication are circular in form and circularly causal, in line with the Macy conference focus on "circular causal and feedback systems"; and that circularity is at the heart of cybernetics. How does this change how we construct our world?

Understanding and Acting

Consider understanding and acting. Acting is commonly considered to be predicated on understanding. Yet psychologists (particularly Jean Piaget)[46] working on how conceptualization develops in children show us that, to develop understanding, babies need to act. In human development, if there is any precedence, or any sense of talking about precedence, acting comes before understanding in our cognitive development. Understanding comes from acting, and, in turn, shapes our acting: another cybernetic circularity, and a good one. We need both, each influencing the other. We need to consider the whole rather than a simpler linearization of that whole.

We can understand this relationship when we consider different types of knowledge that may satisfy different aims. I have argued that (second-order) cybernetics and design are complementary.[47] Whereas science constructs knowledge of the world as it is (i.e., understanding), design is interested in changing that world: it wants knowledge for change (acting). The difference is captured in the prepositions "of" and "for."[48] Knowledge for acting leads to new things of which we then gain knowledge. The trick is figuring out how to move from knowledge of what is into effective action, completing another virtuous circle.

Theory and Practice

We may reconceptualize this redrawn relationship between acting and understanding to illuminate the relationship between theory and practice. We have learned to give precedence to theory. But, substituting theory for understanding, practice for acting, we see this relationship also as circular. Giving precedence to understanding/theory brings great dangers of distorting our relationship with our experience. There is a risk rooted in the question of appropriateness that, while it can offer novel options, can equally remove options that properly belong in practice but are absent in the theory. Using examples from Eric Berne's transactional analysis, Graham Barnes shows the danger that patients may be damaged when theory is allowed to dominate practice in psychotherapy.[49] Humans construct patterns to move out of the continuous flow of experience: we create theories derived from our experiences, bringing them together and shaping a world view in a circular act of cybernetic unification. But when we allow pattern to dominate our experience, we can end in conflict and psychological distress.

When we don't pay attention to practice, to what happens in the world of action, we can mislead ourselves greatly. This is what happens all too often when we assume the linear. The circularity of second-order cybernetics helps us guard against this sort of error.

We who often talk of the application need also to be careful of the word "application" (e.g., of theory to practice). Application involves a hierarchical "power play." In conventional cybernetic terms, the application of a theory means the theory is placed over (and hence restrictively controls) practice. This undermines cybernetic circularity. It runs the risk Barnes so clearly demonstrated.[50] Application is an inappropriate concept for the relationship that should hold between practice and theory. This argument means we do not have to accept the priority of that current major driver, utility. Stafford Beer liked to talk of cybernetics as the science of effective action and efficacity: effectiveness is far more valuable and important than efficiency.[51]

Mind and Body

As a final example, consider the great Cartesian duality between mind and body. Think how, in Western culture, we insistently return to the material, requiring that all existence should be subject to that interesting abstract construction, "laws of physics." We talk of mind depending on body, but from a human point of view, the laws of physics are of little interest if we are without mind: hence, Ashby asserts cybernetics is the study of the immaterial aspects of systems. This is not to deny the value of the material, only to insist that it is a necessary primitive condition. On the contrary, we could argue that mind must have precedence over matter: without mind, the existence of the material world is a matter of no concern. James Clerk Maxwell, inventor of the Black Box, described the situation perfectly: "The only laws of matter are those that our minds must fabricate, and the only laws of mind are fabricated for it by matter."[52]

As Bateson insists, there is no schism: mind and body need each other—the ultimate statement of the holistic explanation of experience.[53] For myself, I think of the embodiment of my mind: how I behave is shaped by my body. I cannot imagine that a brain transplant (assuming mind and brain are connected) could result in more than locked-in syndrome.[54]

Mechanisms of Circularity

We can also explore the mechanisms of circularity. Cybernetics has been especially interested in three of these.

Recursion

The concept of recursion matches the concept of circularity. Meaning "to run back," it refers to progression through a circularity: as we go around and around, we return to each point where we were earlier. In effect, we spiral through the circularity and must create our understanding of identity each time we pass over a "same" point. Studies of recursion allow us to better understand how circularity functions. Recursions tend toward fixed points—but, having reached them, they continue to recurse around these fixed points endlessly. Eigenforms (see below) give us good examples.

Reflection and Reflexion

One expression of cybernetic recursiveness is reflection/reflexion, which have a common origin but have developed differing meanings. The centrality of reflection/reflexion in second-order cybernetics was recognized in Frederick Steier's 1991 book *Research and Reflexivity*, including essays by Foerster, Glasersfeld, and Krippendorff.

Reflection entails deep consideration. There is an element, too, of throwing back (in the mirror). In his work *The Reflective Practitioner*, Donald Schön uses both of these meanings.[55] In the 1980s, Schön (who trained as a philosopher and became an educationalist and urban planner committed to a systems view) was concerned that both the way of learning and the knowledge of professional practitioners were ignored and even dismissed by others who believed they owned learning and knowledge. Following a series of studies, he argued that professional practitioners had a way of learning that he called reflection in action: a process of both contemplating and evaluating what they had been doing in their practice and reflecting this back in a circle to create improvement. Schön's work thus places cybernetic circularity, in the form of reflection, at the center of approaches to research, linking theory and practice in a powerful assertion of the viability and centrality of circularity.[56]

Although reflexion is an archaic spelling of reflection, I find it useful to differentiate the two thus: Reflection involves a change in the actor-agent (and is thus clearly in tune with second-order cybernetics), whereas reflexion is more of a systems behavior. An example is the reflexivity theory of George Soros, which Soros developed in economics.[57] Several cyberneticians consider this theory to exemplify second-order cybernetics.[58] Although developed by one of the world's great financiers, it has not found a large audience among economists, who, apparently, still hope to produce a classic, scientific model of economic working, with no room for involving the observer or the actor-agent. It is little wonder the world's finances are in a mess!

Foerster's "Through the Eyes of the Other" (in Steier's book) gives a powerful depiction not only of a circular, reflective (my spelling) process, but also of how the reflective mechanism allows us to build our personal identities through social interaction.[59] Foerster's position is that we learn to understand, even to form ourselves, as we interact with others, seeing ourselves as we understand they see us. The reflexive unit of this process is not the individual, but the interaction between two individuals forming a unit. Reflectivity is thus allied to conversation, creating self-understanding and self-worth: it is indeed central not only to cybernetics but to being human.

Self-Similarity

We may also consider self-similarity (the parts of which a whole is made have similar form to the whole) a variety of circularity and recursion. As a Mandelbrot set reproduces its (fractal) geometry at all levels (scales), so many cybernetic systems do the same. Perhaps best known of these is Beer's 1985 Viable Systems Model, which is intended to provide similar steering and level-jumping resources at all levels of a management system. Beer's model describes a minimum set of criteria for any particular viable system, as well as the recursive nature of viability itself.[60]

Eigenforms

Foerster also pointed us in the direction of eigenforms. An eigenform (from the German "eigen" = self) is a form that, through its own processes, produces and reproduces itself. Eigen processes are thus recursive, and closely related to autopoiesis. Foerster considers them, for instance, as demonstrations of processes that mimic what children do, learning to populate their worlds with what Piaget calls constant objects. Eigen processes lead to a value that, as the process is repeated recursively, remains unchanged. Foerster called these "Eigen Objects."[61]

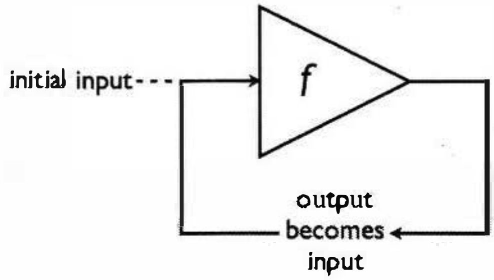

Diagram 3.5 When the function f produces, recursively, an output that converges on and then retains some constant value, it may be called an eigen-function, which operates to produce an Eigen-Object (the whole of the drawing) with an eigen-value. For instance, if the eigen-function is (÷ 2 + 1), the system will quickly stabilize as an Eigen-Object with an eigen-value of 2 (test it) (after Foerster. Although the illustration uses numbers, Foerster did not intend it to be restricted to the numerical.)

Louis Kauffman, whose cybernetic mathematics is a playground of ideas and a constant joy, regularly explores recursion, reflexivity, and eigenforms (along with distinctions, topology, knots, and many other marvels) in a regular column in the journal *Cybernetics and Human Knowing*. In his cybernetic work, he searches for the moments when a mathematical proposition loses its focus, in order to find a new interpretation in the unresolved and paradoxical. However, maybe as important as the work Kauffman produces is the delight he has in doing second-order mathematical cybernetics, for in this he reminds us that cybernetics is something done, a way of acting, not just a study.

Much of Kauffman's thinking derives from George Spencer Brown's *Laws of Form*.[62] This seminal study developed a logic of distinctions, sometimes also called a boundary logic, based on the notion that we bring worlds into being by the act of drawing distinctions, and composing our distinctions together. It can, thus, be seen as a constructivist logic, and it inspired much second-order cybernetic thinking, including my own.

On publication, *Laws of Form* was understood immediately to be of enormous significance. Beer reviewed it for *Nature,* and Foerster (very unconventionally) reviewed it in *The Whole Earth Catalogue,* the 1970s handbook for alternative living and thinking. Foerster used the opening command, "Draw a Distinction," as the abstract of his paper "On Constructing a Reality" (Foerster 1973). Eigen Objects could be said to mimic Piaget's constant objects by constantly distinguishing themselves.

Objects

There is one final cybernetic circular system, introduced because it can be argued it is the primitive second-order cybernetic system. This system is described in the theory of objects, which is founded on both circularity and observing. Second-order cybernetics gives primacy to observing. What sort of organization might be proposed that could be observed differently by each observer and yet taken to be the same thing? The Theory of Objects proposes a self-observing circular system in which observing involves a switch between being observed and observing (Foerster's first- and second-order cybernetic observation), that is, a switch between the roles of the (self-)observed and (self-)observing. These entities are called Objects (Glanville 1975).

The role switch generates both time and empty slots (when an Object is self-observed, it is not self-observing, so another Object could fill the observing slot, observing it). Using temporal synchronicity to establish logical arrangements gives external observers the chance both to enter into observing and to establish relationships between (observations of) Objects—the necessary prerequisite for not only logic but also representation and communication, and hence the whole subject matter of cybernetics.

In the Theory of Objects, the continuing, circular switching between (self-)observing and (self-)observed generates time—by that very act of

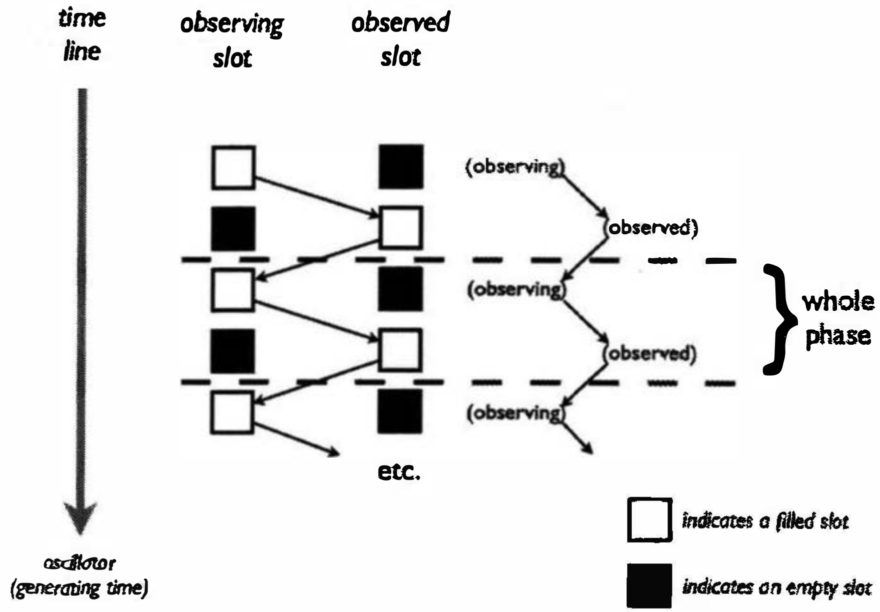

Diagram 3.6 This is a diagram of an Object. It should be read from top to bottom. The "filled" slots are white, the empty black. There is a sequence indicated by the arrows, where a filled (self)observing slot switches to fill a (self-)observed slot and back again to fill a (self-)observing slot, etc., creating a timeline progression. When a (self-)observed slot is empty, another Object may observe through it. In the Theory of Objects, a special formulation is captured to express this.

switching back and forth between the slot for observing and the slot for being observed, each Object being an oscillator, a clock. Switching leaves empty slots. The theory holds that when an Object is self-observed it is not self-observing. The resulting vacant slot may be filled by another Object. Thus, another Object (external observer) than the self may observe that Object. For this to happen, the two Objects must have a degree of synchronicity in order that the empty slot can be filled.

The coming together of two clocks allows an external observation to be made. The coming together in partial synchronicity of several clocks allows logical relationships between the observations of various Objects: the theory proposes, for instance, that if the times of observation by an externally observing Object of two other Objects is exactly the same, there is a logical identity, which may be used either to establish the relationship "same," or to have one of the two Objects "represent" the other. Thus, the basics of observation of one Object by another, and of how we can relate Objects together, is inherent in these structures that the theory names Objects.

Through their structure, Objects allow each of us the freedom to make the meanings we make and the freedom to construct our world as we see fit. Objects are essentially libertarian, providing maximum support for a world full of individual difference rather than assumed and imposed uniformity. For some reason, possibly to do with its extreme abstraction, this pre-ontological (as Scott has called it) foundational work remains little known even in cybernetics.[63]

SUMMARY

We have explored the origins and early history of (modern) cybernetics and some aspects of its relationship to systems. It is probably fair to say that they share similar grounds: that cybernetics is more dynamically based and philosophical and that systems theory is more concerned with the pragmatics of utility. We have considered the way cybernetics moved from inquiring into "circular causal and feedback mechanisms in biological and social systems" to become a technology and how it became divorced from computing and AI, and have examined some of its key concepts—how they work, how they interrelate, and what they offer us.

And we have come full circle, exploring cybernetic consistency (which we contrasted with scientific repeatability) and its expression in second-order cybernetics, which returns us through, for instance, Foerster, Maturana, and Pask (present in the early days) to authors such as Rosenblueth, Mead and Bateson, Ashby, and even Wiener himself, and to the key concepts of (modern) cybernetics: circularity and the inevitability of the observer's presence. We have examined some consequences of thinking within circularity, of how this changes our conception of stability, of goal, of self, of communication and control—without throwing away the benefits of technological, first-order cybernetics—and of some explorations of what circularity means as recursion, reflection/reflexion, and in eigenforms.

We could do worse than to end by requoting Glasersfeld: "Cybernetics is a way of thinking, not a collection of facts."[64] To which I would add: Cybernetics is not just about understanding, but also action: cybernetics is not only to solve problems, but to be lived.

ACKNOWLEDGMENTS

My thanks to the editor and to Roger Harnden, Aartje Hulstein, Lou Kauffman, and Bernard Scott for their help, critical assessment, and input. I, however, gratefully accept responsibility for all errors. After all, I am a cybernetician.

NOTES

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14. Jean Piaget, *The Child's Construction of Reality* (New York: Basic Books, 1955).
15. See Ranulph Glanville and Leon van Schaik, "Designing Reflections: Reflections on Design" in *Proceedings of the Third Conference, Doctoral Education in Design,* eds. D. Durling and K. Sugiyama (Chiba: Chiba University, 2003).
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17. See, for example, Heinz von Foerster, "On Self-Organising Systems and Their Environments," in *Self-Organising Systems,* eds. M. C. Yovits and S. Cameron (London: Pergamon, 1960), 1–20.
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19. W. Ross Ashby, "General Systems Theory as a New Discipline," in *Facets of Systems Science,* ed. George J. Klir (New York: Plenum Press, 1991), 249–57. Originally published in *General Systems* 3 (1958): 1–6.
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32. See Margaret Mead, *Coming of Age in Samoa: A Psychological Study of Primitive Youth for Western Civilisation* (Harmondsworth: Penguin Books, 1954).
33. See Glanville 1997, "A Ship without a Rudder"
34. See Glasersfeld's "Why I Consider Myself a Cybernetician," *Cybernetics and Human Knowing* 1, no. 1 (1992): 21–25.
35. Ernst Von Glasersfeld, "Aspects of Constructivism: Vico, Berkeley, Piaget," in *Key Works in Radical Constructivism,* ed. Ernst von Glasersfeld (Rotterdam: Sense, 2007).
36. Glasersfeld, "Aspects of Constructivism." Cf. Popper, *Conjectures and Refutations* (London: Routledge and Kegan Paul, 1963).
37. Ranulph Glanville, "Radical Constructivism = Second Order Cybernetics," *Cybernetics and Human Knowing* 19, no. 4 (2012): 27–42.
38. See Bärbel Inhelder, Rolando Garcia, and Jacques Voneche, eds. *Epistémologie Génétique et equilibration: Hommage à Jean Piaget* (Neuchatel: Delachaux et Niestle, 1977), 61.
39. Glasersfeld, "Aspects of Constructivism," 97.
40. For a general survey of second order cybernetics, see Glanville 2002.
41. Weinberg, "The Simplification of Science."
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